WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
CONTRACT ADMINISTRATION DIVISION

MATERIALS PROCEDURE

GUIDE TO DESIGNING HOT-MIX ASPHALT USING THE SUPERPAVE VOLUMETRIC DESIGN SYSTEM

1.0 PURPOSE

1.1 To establish an approved volumetric design system, test procedures, and evaluation criteria for hot-mix asphalt (HMA). If recycled asphalt pavement (RAP) is used in the design, refer to MP 401.02.24 for additional guidance.

2.0 SCOPE

2.1 This procedure is applicable to design tests conducted for the purpose of establishing mixture proportions for hot-mix asphalt using the Superpave mix design method.

3.0 APPLICABLE DOCUMENTS

3.1 AASHTO T166: Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

3.2 AASHTO T209: Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

3.3 AASHTO T269: Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures

3.4 AASHTO TP4: Determining the Density of HMA Specimens by Means of the Superpave Gyratory Compactor

3.5 AASHTO PP28: Practice for Superpave Volumetric Design for HMA

3.6 AASHTO MP2: Specification for Superpave Volumetric Mix Design

3.7 AASHTO PP2: Practice for Mixture Conditioning of HMA

3.8 AASHTO T84: Specific Gravity and Absorption of Fine Aggregate

3.9 AASHTO T85: Specific Gravity and Absorption of Coarse Aggregate

3.10 AASHTO T30: Mechanical Analysis of Extracted Aggregate

3.11 AASHTO T283: Resistance of Compacted Bituminous Mixture to Moisture Induced Damage

4.0 TESTING REQUIREMENTS

4.1 The laboratory performing the design shall be a Division approved laboratory. To obtain Division approval, a laboratory must demonstrate that they are equipped, staffed and managed, for batching and testing hot-mix asphalt in accordance with AASHTO standard procedures. This shall be accomplished by submitting a copy of their latest report of inspection by the AASHTO Materials Reference Laboratory (AMRL) to the District Materials Section. They must also submit a letter detailing the actions taken to correct any deficiencies noted in the test procedures listed below. The District will forward this information to the Contract Administration Division, Materials Section. It is also required that the design laboratory request to be included on AMRL's routine schedule of inspections which is usually every 20 to 24 months in order to maintain their approval status.

(1) AASHTO TP4 - Determining the Density of HMA Specimens by Means of the Superpave Gyratory Compactor
(2) AASHTO T166 - Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
(3) AASHTO T209 - Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
(4) AASHTO T308 (formerly TP53) - Asphalt Content of HMA by the Ignition Method (Test Method A)
(5) AASHTO T84 - Specific Gravity and Absorption of Fine Aggregate
(6) AASHTO T85 - Specific Gravity and Absorption of Coarse Aggregate
(7) AASHTO T30* - Mechanical Analysis of Extracted Aggregate

* AASHTO T27, Sieve Analysis of Fine and Coarse Aggregates, together with T11, Materials Finer Than No. 200 (75 µm) Sieve in Mineral Aggregates by washing, may be substituted for AASHTO T30.

An essential portion of the staffing requirement is a technician who has had Division approved training in the Superpave mix design method. A list of the approved design laboratories and approved design technicians will be maintained by the Division.

4.2 The mix design properties shall meet the requirements of Table 401.02.28A and shall consist of the following:

4.2.1 Percent Air Voids: AASHTO T269

4.2.2 Percent Voids in Mineral Aggregate (VMA): AASHTO PP28

4.2.3 Percent Voids Filled With Asphalt (VFA): AASHTO PP28

4.2.4 Fines to effective asphalt (FA) ratio: AASHTO PP28

4.2.5 Tensile Strength: AASHTO T283

TABLE 401.02.28A
Volumetric Mix Design Criteria

Design air voids	4.0 %
Fines to effective asphalt (FA) ratio (Note 1)	0.6 - 1.2
Tensile strength ratio (AASHTO T283) (Note 2)	80 % minimum

	Nominal Maximum Size				
	37.5 mm (1 ½")	25 mm (1")	19 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")
Minimum Voids in Mineral Aggregate (VMA) %	11.0	12.0	13.0	14.0	15.0

Design ESALs (millions)	Percent of Theoretical Maximum Specific Gravity			Percent Voids Filled With Asphalt (VFA) (Notes 3, 4, & 5)
	$N_{initial}$	N_{design}	N_{max}	
< 0.3	≤ 91.5	96.0	≤ 98.0	70 – 80
0.3 < 3	≤ 90.5	96.0	≤ 98.0	65 – 78
3 < 10	≤ 89.0	96.0	≤ 98.0	65 – 75
10 < 30	≤ 89.0	96.0	≤ 98.0	65 – 75
≥ 30	≤ 89.0	96.0	≤ 98.0	65 – 75

Note 1: When the design aggregate gradation passes beneath the boundaries of the aggregate restricted zone, the dust-to-binder ratio criteria shall be 0.8 – 1.6.

Note 2: Test specimens shall be 150 mm in diameter and 95 mm in height. If the 80% minimum tensile strength ratio is not met, a new design will be required. A Division approved antistripping additive, such as hydrated lime conforming to the requirements of AASHTO M303 or a liquid antistripping additive, may be added to the mixture if needed. If such an additive is used, all design testing must be conducted with the additive in the mixture.

Note 3: For 9.5 mm (3/8") nominal maximum size mixtures, the specified VFA range shall be 73% to 76% for design traffic levels $\geq$ 3 million ESALs.

Note 4: For 25 mm (1") nominal maximum size mixtures, the specified lower limit of the VFA shall be 64% for design traffic levels < 0.3 million ESALs.

Note 5: For 37.5 mm (1 1/2") nominal maximum size mixtures, the specified lower limit of the VFA range shall be 64% for all design traffic levels.

4.3 The design gradation shall meet the requirements of Table 401.4.2 of the Specifications for the specified mix type. The percent passing each sieve contained in this table, from the nominal maximum size down to the No. 200 (75 µm), shall be included in all gradation calculations. The design shall be developed using the volumetric design guidelines provided in AASHTO PP28. The gyratory compaction criteria shall be in accordance with Table 401.02.28B based on the projected 20 year design ESAL value supplied in the contract documents. The design PG Binder shall be a PG 64-22 unless otherwise specified in the contract documents. The HMA shall be coarse graded with the 0.45 gradation plot falling between the specified control points and also crossing underneath the restricted zone as described in AASHTO MP2.

TABLE 401.02.28B
Gyratory Compaction Criteria (Note 6)

20 Year Projected design ESALs (millions)	Compaction Parameters (Note 7)		
	N_I	N_d	N_m
< 0.3 (Light Traffic)	6	50	75
0.3 to < 3 (Medium Traffic) (Note 8)	7	75	115
3 to < 30 (Heavy Traffic)	8	100	160
≥ 30 (Extra Heavy Traffic)	9	125	205

Note 6: For design traffic levels of ≥ 3 million ESALs, specifications or contract documents may require that the JMF gyratory compaction criteria for mixtures located ≥ 4 inches (100 mm) below the pavement surface be lowered by one ESAL level. Also, if a different binder grade is required in mixtures located ≥ 4 inches (100 mm) below the pavement surface, this information will be provided in the specifications or in the contract documents. If less than 25% of the mixture layer is within 4 inches (100 mm) of the surface, the layer shall be considered to be below 4 inches (100 mm) for design purposes.

Note 7: Samples used for determining the optimum asphalt content of the mixture shall be compacted to N_{design} in accordance with AASHTO TP4. After the optimum asphalt content is determined, a set of specimens containing the selected aggregate structure at the design asphalt content shall be compacted to N_{max} to verify that the percent theoretical maximum density at N_{max} satisfies the design criteria of Table 401.02.28.A.

Note 8: When the design ESALs are between 3 to < 10 million ESALs the Division may elect to specify the gyratory compactor parameters to match the medium traffic level of 0.3 to < 3 million ESALs. When this decision is made, contract documents will contain all necessary information relating to the change.

4.4 The aggregate used in the mix design shall meet the requirements of Section 703.1-3, 702.3, and 702.4 of the Standard Specifications with exceptions and additions as noted in Table 401.02.28C.

TABLE 401.02.28C
Aggregate Property Requirements (Note 9)

20 Year Projected Design ESALs (millions)	Coarse Agg. Angularity (% Minimum) ASTM D5821 (Note 10 and 11)		Fine Agg. Angularity (% Minimum) AASHTO T304, Method A (Note 12)		Fine Agg. Sand Equivalent AASHTO T176	Coarse Agg. Flat and Elongated ASTM D4791
	≤ 100 mm From Surface	> 100 mm From Surface	≤ 100 mm From Surface	> 100 mm From Surface	% Minimum	% Maximum (Note 13)
< 0.3	55 / -	- / -	-	-	40	-
0.3 to < 3	75 / -	50 / -	40	40	40	10
3 to < 10	85 / 80	60 / -	45	40	45	10
10 to < 20 (Note 14)	90 / 85	80 / 75	45	40	45	10
10 to < 30	95 / 90	80 / 75	45	40	45	10
≥ 30	100/100	100/100	45	45	50	10

Note 9: The aggregate property requirements shall be applied to the blend of coarse and fine aggregates within a mixture. The properties of the blended coarse aggregates may be obtained by mathematical proportioning if one or more of the aggregates in the blend fail one or both of the required properties. The properties of the blended fine aggregates must be obtained by actual testing of the blended materials if one or more of the aggregates in the blend fail one or both of the required properties

Note 10: Depth from surface shall be interpreted to mean that if less than 25% of a layer is within 4 inches (100 mm) of the surface then the greater-than 4 inches (100 mm) criteria shall apply.

Note 11: "85/80" denotes that a minimum of 85% of the coarse aggregate has one fractured face and a minimum of 80% has two fractured faces.

Note 12: Fine aggregates sizes that are coarse graded and have only a small amount of minus 600 µm (No. 30) material often cannot be individually tested using Method A. Such aggregates must be blended with the other fine aggregates of the mixture to the specified mix design proportions before testing can be conducted. For testing purposes, samples of all the fine aggregates used in the JMF mixture must be supplied to the Materials Section along with the mix design blend proportions.

Note 13: Flat or elongated particles in coarse aggregates shall be tested in accordance with ASTM D4791 for a maximum to minimum ratio of 5:1. The amount of coarse aggregate exceeding this ratio shall be a maximum of ten percent by weight for all pavements where the estimated traffic level is $\geq$ 0.3 million ESALs.

Note 14: The 10 to < 20 million design ESAL aggregate criteria only applies to Section 402 skid resistant designs.

5.0 REPORT

5.1 The T-400 JMF Form shall include the design property information required in Section 401.4 of the Specifications. JMF submittals shall include all Superpave mix design software printouts from the specimen compaction and analysis covering the required mix properties. In addition, if not automatically generated through the mix design software, the following information must be included:

5.2 A summary sheet showing the optimum asphalt content determination plus the design properties compared to the design criteria of Table 401.02.28B.

5.3 Worksheets showing calculation for bulk, apparent, and effective specific gravities and absorption of the aggregates used in the mix design.

5.4 Worksheets showing calculations for maximum specific gravities of the mix at different asphalt contents.

5.5 The 0.45 power gradation chart developed for each mix design.

5.6 A worksheet showing the calculations for the combined aggregate of the mix design.

5.7 Worksheets showing the washed sieve analysis results for each aggregate used in the mix design.

5.8 The temperature-viscosity chart for the asphalt used in the mix design. A supplier issued statement containing the mix and compaction temperature recommended for the specific grade of asphalt may be included in lieu of the chart.

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